Global Energy Future after the Fukushima Nuclear Accident

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Note: The views expressed here are of my own and do not necessarily reflect those of the JAEC nor the government.
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Summary

• Fukushima Dai-ichi nuclear power accident has become one of the worst accidents in nuclear history and it is not completely over yet. The biggest impact is loss of public trust. This has serious implications for not only Japan but also global nuclear energy development.

• Impact of shale gas, improved energy efficiency and expansion of renewables are the new trends in global energy scenes. Still, challenges for climate change remains.

• Need all technology options to meet climate challenge and appropriate policy mix is necessary.

• Global negotiation on climate change is facing difficulties and need innovative approaches, such as putting carbon price, are necessary.
The Fukushima Nuclear Accident
Personal Reflections on the Fukushima accident

• *Feel deep responsibility and regret for what happened as a person/expert engaged in nuclear energy. Would like to express my sincere apology for all people affected by the accident.*

• Fundamental shift in thinking about risk of nuclear energy.
  – Risk is as large as risks of nuclear proliferation and nuclear security (I thought nuclear safety risk is smaller)
  – Social/political/economic risks are tremendously larger than I thought. It has become an issue of human security.
  – Protection of human lives is not good enough. Release of radioactive materials which would cause long term impacts on society and environment should not be allowed.
  – About 150,000 people are still not living in their own homes and are concerned about their health, future life and future of their homeland. It is heartbreaking to listen to their story, with anger, frustration and anxiety.

• Assuring and restoring life and welfare of people affected by the accident is the top priority.
Current Status

- It will take at least 30 years to clean up and decommission the Fukushima Dai-ichi site.
- Total liability (compensation) amount is estimated to be at least 6 trillion yen ($60 billion) which is likely to grow further.
- Only two (out of 50) nuclear plants are operating, but due to energy conservation/efficiency improvement efforts no power shortage occurred during this summer peak. Still about 3.5 trillion yen ($35 billion) was paid more for fossil fuel than last year. All utilities except Hokuriku and Okinawa suffered largest loss (total of 1.3 trillion yen in FY 2012).
- Newly established Nuclear Regulatory Authority (NRA) has been working on new regulatory standards and published its draft. NRA published the standard for reactors in July and plans to publish the standard for nuclear fuel cycle facilities by December. Until its safety is confirmed in accordance of the standards, no reactors/facilities are not allowed to start up.
Mid-Long Term Roadmap for Fukushima Dai-ichi

**Mid-to-Long-Term Roadmap towards the Decommissioning of Fukushima Nuclear Power Units 1-4**

**Step 1, 2**
- Achieved Stable Conditions
- Reactors: A condition equivalent to Cold Shutdown
- Spent Fuel Pools: More stable cooling
- Radioactive Contaminated Water: Reduction

**Phase 1**
- Period to the commencement of the fuel removal from the Spent Fuel Pools (Within 2 years)
  - Commence the removal of fuels from the spent fuel pools (Unit 4 in 2 years)
  - Reduce the radiation impact due to additional emissions from the whole site and radioactive waste generated after the accident (secondary waste materials via water processing and debris etc.) Thus maintain an effective radiation dose of less than 1 mSv/yr at the site boundaries caused by the aforementioned.
  - Maintain stable reactor cooling and accumulated water processing and improve their credibility
  - Commence R&D and decontamination towards the removal of fuel debris

**Phase 2**
- Period to the commencement of the removal of fuel debris (Within 10 years)
  - Complete the fuel removal from the spent fuel pools at all Units
  - Complete preparations for the removal of fuel debris such as decontaminating the insides of the buildings, restoring the PCVs and filling the PCVs with water
  - Commence the removal of fuel debris (Target within 10 years)
  - Continue stable reactor cooling
  - Complete the processing of accumulated water
  - Continue R&D on radioactive waste processing and disposal, and commence R&D on the reactor facilities decommission

**Phase 3**
- Period to the end of the decommissioning (In 30-40 years)
  - Complete the fuel debris removal (in 20-25 years)
  - Complete the decommission (in 30-40 years)
  - Implement radioactive waste processing and disposal

**Present (Step 2 Completed)**
2011/12

**Within 2 Years**
2013/05

Source: M. Yasui, Nuclear and Industrial Safety Agency (NISA), March 2012,
Evacuation Area Amended (March 7, 2013)

(As of April 29, 2012)

(Dec 10, 2012)

(After April 1, 2013)

Compared with the Chernobyl accident

Cherry blossom in Tomioka Town
(10 km from Fukushima Daiichi)


Most Important Lessons Learned from Fukushima: “Thinking Unthinkable” and “Resilience”

• “The Investigation Committee is convinced of the need of a paradigm shift in the basic principles of disaster prevention programs for such a huge system, whose failure may cause enormous damage.” – from the Interim Report by the Gov’t investigation committee (Dec. 2011)

• “Thinking unthinkable” is essential in preparing for the emergency and for energy security.

• “Resilience” beyond “defense in depth” is needed for preparing “unexpected crisis”.
  – Resilience means a capability to respond to “unexpected crisis” as well as to restore safe and secure status of the social system.
Japan’s energy policy after 3/11
Goal of Power Production Mix in 2030
Before 2011/3/11

- Renewable: 10.2%
- Hydro: 9.2%
- Nuclear: 48.7%
- LNG: 14.2%
- Coal: 14.0%
- Oil: 3.8%

Source: Institute of Energy Economics, March 2010

2004

資本費 +0.2円
運転維持費 +1.0円
核燃料サイクル ▲0.1円
追加の安全対策 +0.2円

資本費 +0.2円
+1.1円
政策経費 +1.1円

Capital cost
O&M
Fuel cycle
Additional cost

2011

5.9円

Costs associated with accident

8.9 yen/kWh if total accident costs is 6 trill yen. It will increase 0.1 yen/kWh if total accident costs increase 1 trillion yen.

出所:コスト等検証委員会報告書、2011年12月19日
Nuclear power can be competitive, but social costs can be high…
What is your opinion about nuclear power in Japan?

What sources do you think are most “untrustworthy”?

Source: Prof. Hirotada Hirose, “Changes of Public Opinion about Nuclear Power,”
Presented at Japan Atomic Energy Commission, July 17, 2013
Do you think a similar scale of nuclear accident will happen again?

Summary of Innovative Energy and Environmental Strategy (2012/09/14)

1. Realization of a society not dependent on nuclear power in earliest possible future (see the next pages)

2. Realization of a green energy revolution
   – Compose the “Framework for Green Development Policy” by the end of this year
     (1) Power saving: more than 110 billion kWh (~10%) by 2030
     (2) Energy saving: more than 77 million kl (~19%) by 2030
     (3) Renewable energy: more than 300 billion kWh (three times) by 2030

3. Stable supply of energy
   (1) Intensive use of thermal generation
   (2) Intensive use of heat, including cogeneration
   (3) Technologies related to the next generation energy
   (4) Stable and inexpensive securement and supply of fossil fuels

4. Reform of the electric power system

5. Steady implementation of measures against global warming

Summary of New Energy and Environmental Strategy (2012/09/14) (on nuclear energy policy)

Realization of “Society not dependent on nuclear power” in earliest possible future

- Mobilize all possible policy resources to such a level as to even enable zero operation of nuclear power plants in the 2030s.

(1) 3 Principe guidelines
- Strictly apply 40-year limitation of reactor operation
- Restart the operation of nuclear power plants once the Nuclear Regulation Authority gives safety assurance
- Not to plan the new and additional construction of a nuclear power plant

(2) 5 policies to achieve society without dependent on nuclear power (later)

(3) Review and constantly re-examine the path towards realization of a society not dependent on nuclear power

PM Abe’s Statement at Diet on Energy Policy (2013/02/28)

• Reflecting on the accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station, under the Nuclear Regulation Authority, we will foster a new culture of safety that will uncompromisingly enhance the degree of safety. After doing so we will restart nuclear power plants where safety has been confirmed.

• We will promote the introduction of energy conservation and renewable energies to the greatest possible extent to reduce our degree of dependency on nuclear power as much as possible. At the same time, we will begin a fundamental reform of the electric system.

http://www.kantei.go.jp/foreign/96_abe/statement/201302/28siseuhousin_e.html
Impact on Global Nuclear Energy Development
From “Nuclear Renaissance” to “Failed Dream”? by “The Economist”

“A nuclear revival is welcome so long as the industry does not repeat its old mistakes”
-- The Economist, September 8, 2007

“For nuclear to play a greater role, either it must get cheaper or other ways of generating electricity must get more expensive.” – The Economist, March 10, 2012
Global Nuclear Power Development Current Status (IAEA)

As of July 31, 2013, 434 nuclear power plants (370.5 GWe) are operating and 69 units are under construction, one unit in long term shutdown.  

http://www.iaea.org/pris/
Global Nuclear Power Plant Construction (IAEA) : Replacement of old reactors are coming.

Construction starts

Global Nuclear power production is in decline

http://www.worldnuclearreport.org/
Asia: No major policy changes, still committed to nuclear power

Bangladesh: There is no change in plans to promote nuclear policy. Bangladesh signs with agreement between Russia about the construction of Rooppur NPP in November 2011.

China: Important role of nuclear power in China is not changed. China has temporarily stopped the authorization of new projects after the accident, but the construction of NPP has restarted now.

India: Domestic energy demand is increasing, and nuclear power is considered to be an important option as a clean energy source (no change). Construction of new NPPs are progressing according to the existing plan.

Indonesia: 49.5% of the population is in favor (35.5% opposition) for against nation’s nuclear policy. Nuclear power is considered as one of the main power source to support energy security.

Kazakhstan: There is no change in plans to promote nuclear power. many people are aware that there is no other option to incorporate nuclear power for the realization of nation’s policy.

South Korea: There is no change in nuclear policy. Based on the "4th Comprehensive Nuclear Energy Promotion Plan", South Korea continues to build NPPs in six locations from 2012 to 2017.

Malaysia: There is no change in plans to begin the operation of Malaysia's first nuclear reactor in 2021.

Vietnam: There is no change in plans to promote nuclear power. Vietnam plans to build high safety NPPs learned from Fukushima accident with Japan and Russia in cooperation.

Taiwan: Announced an energy policy to reduce the dependence on nuclear power.

Thailand: Decided the postponement of the plan to build five NPPs for 3 years.
Estimates of Nuclear Electrical Generating Capacity: Comparison of estimates in 2012 and 2011

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Global Energy Trends
Population and income growth...

Population

GDP

Primary energy

Energy Outlook 2030

Industrialisation and growing power demand...

By region

By primary use

By fuel

Energy Outlook 2030

© BP 2013
Energy demand growth is matched by supply...

**Demand vs. Supply**

- **2011**
  - OECD
  - Non-OECD

- **2030 Level**
  - Renew.*
  - Hydro
  - Nuclear
  - Other
  - Shale
  - Tight
  - Other

- **Billion toe**
  - 12
  - 13
  - 14
  - 15
  - 16
  - 17

*Includes biofuels

*Energy Outlook 2030*
Energy prices play a key role...

Shares of world primary energy

- Oil
- Coal
- Gas
- Hydro
- Nuclear
- Renewables*

Energy prices

- Oil - Brent
- Gas - basket
- Coal - basket

$2011/boe

*Includes biofuels
Energy efficiency improvements are critical...

Energy intensity by region

Energy and GDP

*Euro4 (France, Italy, Germany, UK) pre-1970
High oil prices are reducing oil’s share of primary energy...

Oil share of energy and GDP

% of energy

- Oil as % of primary energy
- Cost of oil as % of GDP (RHS)

% of GDP

Oil share in sector

- Transport
- Industry
- Other
- Power
Renewables continue to gain market share...

Share of power generation

Renewable power
Growth 2011-30, and share of power

Energy Outlook 2030
The fuel mix for power generation diversifies...

Growth of fuel inputs to power

Billion toe

Shares of power output

Energy Outlook 2030
Energy Technology Strategy for Sustainable Future

From International Energy Agency

“Energy Technology Perspective 2012”

http://www.iea.org/etp/etp2012/presentations/
ETP 2012 – Choice of 3 Futures

**2DS**
a vision of a sustainable energy system of reduced Greenhouse Gas (GHG) and CO₂ emissions

*The 2°C Scenario*

**4DS**
reflecting pledges by countries to cut emissions and boost energy efficiency

*The 4°C Scenario*

**6DS**
where the world is now heading with potentially devastating results

*The 6°C Scenario*

http://www.iea.org/etp/etp2012/presentations/
Sustainable future still in reach

Is a clean energy transition urgent? **YES ✓**

Are we on track to reach a clean energy future? **NO ✗**

Can we get on track? **YES ✓**
Recommendations to Governments 2012

1. Create an investment climate of confidence in clean energy

2. Unlock the incredible potential of energy efficiency – “the hidden” fuel of the future

3. Accelerate innovation and public research, development and demonstration (RD&D)
Choosing the future energy system

To achieve the 2DS, energy-related CO$_2$ emissions must be halved until 2050.
Decoupling energy use from economic activity

Reducing the energy intensity of the economy is vital to achieving the 2DS.
All sectors need to contribute

The core of a clean energy system is low-carbon electricity that diffuses into all end-use sectors.
A portfolio of technologies is needed

Technology contributions to reaching the 2DS vs 4DS

Energy efficiency is the hidden fuel that increases energy security and mitigates climate change.
Renewables provide good news

Global renewable power generation

42% Average annual growth in Solar PV

75% Cost reductions in Solar PV in just three years in some countries

27% Average annual growth in wind
Fuel economy has improved

Vehicle fuel economy, enacted and proposed standards

The number one opportunity over the next decade in the transport sector, but few countries have standards in place.
Significant potential for enhanced energy efficiency can be achieved through best available technologies.
Low-carbon electricity: a clean core

Global electricity generation in the 2DS

Renewables will generate more than half the world’s electricity in 2050 in the 2DS
Without further action, nuclear deployment in 2025 will be below levels in the 2DS, although a majority of key countries remain committed to nuclear.
Energy RD&D has slipped in priority
The IEA has called for a twofold to fivefold increase in annual public RD&D spending on low carbon technologies to achieve the 2DS.
How much can we reduce GHGs and how much do they cost? (Global, 2007)

Global cost curve for Greenhouse Gas Abatement

The core policy mix

Carbon price, energy efficiency policy and technology support are the backbone of a least-cost package to achieve 2DS.
Public Policy for Climate Change
Main Message

• History of climate change policy debate suggests complex nature of global politics
• Science matters, but conflicts among nations and group of nations seem much more influential
• Not only conflicts between North and South, but conflicts among the North and the South are also important
• Innovative market oriented approaches, such as putting carbon price, are necessary
History of Global Climate Change Policies

- **1972:** UN Conference on Human Environment (Stockholm Conference)
- **1987:** Brundtland Commission in its final report “Our Common Future” -- “Sustainable Development”
- **1988:** Toronto Conference on the Changing Atmosphere (Toronto Conference) - Origin of IPCC
  - basic principle of “common but differentiated responsibilities and respective capabilities” agreed that all parties, including developing countries, take responsibility for implementing global warming measures at different levels.
  - A total of 189 countries, including the United States, participate in the convention.
UNFCCC

• United Nations Framework Convention on Climate Change (UNFCCC) was one of three conventions adopted at the 1992 "Rio Earth Summit."

• Conference of the Parties (COP) is the prime authority of the Convention.

• Ultimate objective of stabilizing greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system."

• Kyoto Protocol is an agreement under the framework of UNFCCC.
“Putting Carbon Price” can be the answer..

We therefore urge policy-makers to focus on introducing a clear carbon price framework in a stable and timely manner, namely:

• Make carbon pricing a central part of national policy responses.

• Work towards the long term objective of a carbon price throughout the global economy.

• Set sufficient ambition through internationally agreed targets to drive change at a pace commensurate with the 2C goal.

Today, countries with carbon pricing mechanisms implemented and scheduled emit roughly 10 GtCO₂e/y, equivalent to 21% of the 50 GtCO₂e emitted globally. If China, Brazil, Chile, and the other emerging economies eyeing these mechanisms are included, carbon pricing mechanisms could reach countries emitting 24 GtCO₂e per year, or almost half of the total global emissions.